GREEN MINI-GRID HELP DESK

Mini-Grid Training Needs Assessment

Gap Analysis for Developers

Report prepared by Energy 4 Impact and Inensus
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Executive Summary

The market for private investment in green mini-grids in Sub Saharan Africa (**SSA**) is still relatively immature, and this is reflected in the lack of skills and experience of developers and other key industry stakeholders. The problem is exacerbated by a lack of mini-grid specific training courses and dedicated local training centres. Training, together with bespoke technical assistance, is therefore critical if mini-grids are to be scaled up.

This report was commissioned by the African Development Bank (**AfDB**) under the Green Mini-grid Market Development Programme and looks specifically at the training needs of mini-grid developers. It identifies the knowledge and skills requirements of developers and evaluates whether their requirements are being addressed by existing and planned training programmes. It makes recommendations on what future training programmes should focus on and identifies potential training organisations that can help fill the gaps.

A. Scope of report

The report analyses all aspects of the training programmes, including types of training, course content, training delivery methods, certification, and the track record and suitability of different training organisations. The report is based on:

- Interviews with 11 developers[1] and the Africa Mini-grid Developers Association (**AMDA**);
- Interviews with 20 training providers and desktop research on 33 other providers;
- Desktop research on 47 training programmes; and
- On-the-ground experience of Energy 4 Impact and Inensus (together the "**Help Desk**") providing technical assistance to over 100 developers in SSA.

B. Requirements of developers

Many mini-grid operators lack the skills, knowledge and experience to develop and run mini-grids properly. A comprehensive mini-grid training curriculum should aim to cover the whole project life cycle from project development and construction through to operation:

- *Project development* – site selection, demand assessment, technical system design and system sizing, distribution network mapping, business models, financial modelling, feasibility studies, capital raising, and project management.
- *Project construction* – contracting, procurement, installation, commissioning, capital raising and financing, and project management.
- *Project operation and maintenance* (**O&M**) – O&M process management and software, marketing and sales, tariff setting, customer service, metering, demand side management, demand stimulation including micro-enterprise development, performance monitoring and evaluation, and enterprise management.

The requirements of developers in terms of subject matter vary widely, depending on the type and experience of the developer and the nature of the staffing role. For example, there are big differences between international and local developers, between single country and regional players, between early stage developers and those with operational plants, between different sizes and technologies of mini-grids, and between executive management and field staff.

At one end of the spectrum, there is a relatively small group of experienced developers that tend to be interested in more targeted training support. At the other end, many other developers have little or no mini-grid experience and require class-room based training covering all aspects of mini-grids.

[1] 9 mini-grid operators and 2 early stage mini-grid developers

International developers usually have better access to technologies, networks and private and public capital than their local counterparts. However, many lack experience working in rural Africa, so require support on local customs, standards, policies and regulations. Local developers, in contrast, know how things work on the ground, but do not necessarily have the required technical, engineering, commercial and financing skills.

Mini-grid training should ideally be adapted for different types of developer staff. For example, the top management need to have a good understanding of the overall business, including the business models, regulations, financing and staff management, while field staff must run the mini-grid operations effectively from a commercial, technical, and customer management and payment perspective.

While the needs of developers may vary in terms of subject matter, there are a number of challenges common to all of them. Many complain about the shortage and high cost of accessing skilled labour in rural areas, such as project managers, sales and after sales staff, and certified electrical engineers. These problems are made worse by the high cost and difficulties of persuading skilled labour in urban areas to work in remote, rural settings. It is partly for these reasons that developers prefer short, practical training courses which address particular skills gaps and can be delivered locally.

C. Existing training programmes

There are many renewable energy training programmes in Africa and globally, but very few of these are mini-grid specific and targeted at developers. Those that do exist are fairly new and tend to be professional development or vocational programmes which are funded by international organizations and implemented by local institutions.

Most programmes have a fairly narrow focus on technical training for engineers and do not adequately cover other mini-grid topics. This is partly because, apart from mini-grid technology and policy, there are no commonly agreed best practices for developing, constructing and operating mini-grids. Training on local mini-grid regulations is also lacking and this is probably a reflection of the lack of clarity and transparency around mini-grid regulations in most African countries.

As part of our research, we have reviewed 36 renewable energy and mini-grid external training programmes and come across 11 on-the-job schemes organised by the developers themselves. We have identified shortcomings in both the content and method of delivery of the external programmes. Some training providers are aware of these shortcomings and are starting to design new programmes, although funding is often a challenge.

C1. Types of training programme

There are four main types of training programme: vocational, professional development, academic, and on-the-job.

- *Vocational training programmes* focus on the practical skills and knowledge required to perform a particular job or task. They usually last several weeks or months and target semi-skilled individuals who want to enter the market or are already active but at an entry level and with lower professional qualifications (e.g. electricians). They tend to be more technical/engineering focused and are usually locally certified and delivered by accredited local training institutions. We reviewed nine of these programmes.
- *Professional development training programmes* are a specialised form of training for individuals that are already in a certain career or job and often include formal and more advanced education. They target more skilled professionals with a formal education background (e.g. engineers) and equip them with professional knowledge and qualifications. They can last several weeks or months. In the renewable energy and mini-grid sector most

professional training providers are technical/engineering focused. Their programmes are not necessarily certified nor standardised, but most are. We reviewed 15 of these programmes.

- *Academic training programmes* are based more around research and academic content in a certain field of study rather than practical experience. The courses are run by universities and training institutions and usually last one to three years, with the student ending up with a degree or equivalent qualification. They are rarely mini-grid specific, but may include mini-grid components as part of a broader curriculum such as renewable energy[2]. We reviewed 12 of these programmes.
- *On-the-job training programmes* are organised by the developers themselves. They are generally informal and often done in the field and designed for field engineers. Some developers are trying to develop more formalised training with manuals etc., others are bringing staff to their home countries for training, while a third group are using external experts to run adhoc training in the field. All 11 of the developers we interviewed had on-the-job training, including the early stage developers.

We also identified a small number of internship programmes[3] and many useful mini-grid tools and resources available online, which could be integrated into the above programmes[4].

C2. Training content

Most of the training courses that exist today for mini-grids are focused on solar technologies, particularly solar engineering.

As the table below shows, there are two key issues:

- *Topics* not well covered by existing training courses e.g. mini-grid business models, capital raising, tariff setting, technical system sizing and distribution grid design, local policies and regulations, health and safety, performance monitoring and evaluation, and O&M process management and software; and
- *Core skills* lacking by developers e.g. project and enterprise management, financial modelling, risk assessment and proposal writing, and these are not being addressed by existing courses.

[2] Some universities have installed their own mini-grids in Africa to improve learning and give their students hands-on experience. These include Southampton University (Kenya, Uganda and Cameroon), Colorado State University (alliance with MeshPower in Rwanda), Notre Dame University (Uganda), Makerere University (Uganda), Strathmore University (Kenya) and University of Saint Augustine (Tanzania).

[3] Some universities such as Carnegie Mellon's Rwanda campus are already placing skilled interns in developers. The DFID-funded TEA program will support skills development in mini-grid developers through internships.

[4] Examples include: Green Mini-grid Help Desk website; HOMER software for mini-grid system design and optimization; PV simulation software such as PVsyst and PV*Sol; Odyssey Energy Solutions; GIZ's Mini-grid Builder; NREL's Mini-grid Quality Assurance Framework and Implementation Guide; Acumen's Energy Impact Series and Lean Data Program; RECP's Mini-grid Policy Toolkit; USAID's Mini-grids Support Toolkit and Practical Guide to the Regulatory Treatment of Mini-grids; and EUEI PDF's Retail Tariff Toolbox and Renewable Energy Tariff Toolbox.

Gaps in mini-grid training content

Training content	**Demand for training from developers**	**Current training provision**	**Gaps in training content**
Business / finance	Mini-grid business models Feasibility studies Capital raising and financing Tariff setting and structuring Billing and metering Demand stimulation Marketing and after sales service Community and stakeholder engagement Financial modelling and reporting	*Partly covered*: Mini-grid business models Capital raising and financing e.g. sources of capital, project financing Tariff models Marketing and sales Community and stakeholder engagement Financial reporting	Mini-grid business and financial model Feasibility studies Capital raising. corporate finance, asset finance, end user finance Tariff setting and structuring Billing and metering Demand stimulation, especially with productive users Marketing, customer agreements and after sales customer service Community and stakeholder engagement
Policy / legal/ regulatory	Local mini-grid policy and regulations Local licensing and approval processes Local procurement rules Local technical standards	*Partly covered*: High level mini-grid policy & regulation, energy planning	Local mini-grid policy and regulations Local licensing and approval processes Local procurement rules Local technical standards
Technical / engineering	Site selection Demand assessment / forecasting Technical system design for generation and grid, including system sizing Procurement and contracting Installation and commissioning Operations	*Adequately covered*: Renewable resource assessment Generation system design Overview of renewable technologies Design simulation *Partly covered*: Site selection Demand assessment Load analysis Installation and commissioning	Demand assessment and forecasting techniques System design and sizing, especially distribution grid design and mapping Procurement and contracting Installation and commissioning Operations & maintenance, including operational management Customer connections, household installations and wiring Demand-side management and end user electrical appliances Remote monitoring and metering
Health & safety	Health & safety for mini-grid staff Health and safety for end users	*Not properly addressed*	Health & safety for mini-grid staff Health and safety for end users

Information and communication technology (**ICT**)	Performance monitoring and evaluation Operation and maintenance (O&M) process software	*Partly covered:* Impact assessment	Data analytics, especially for evaluation of operational performance O&M process software
Core skills	Project and enterprise management Financial modelling Risk assessment and mitigation	*Not properly addressed*	Project and enterprise management Financial modelling Risk assessment and mitigation

C3. Training delivery models

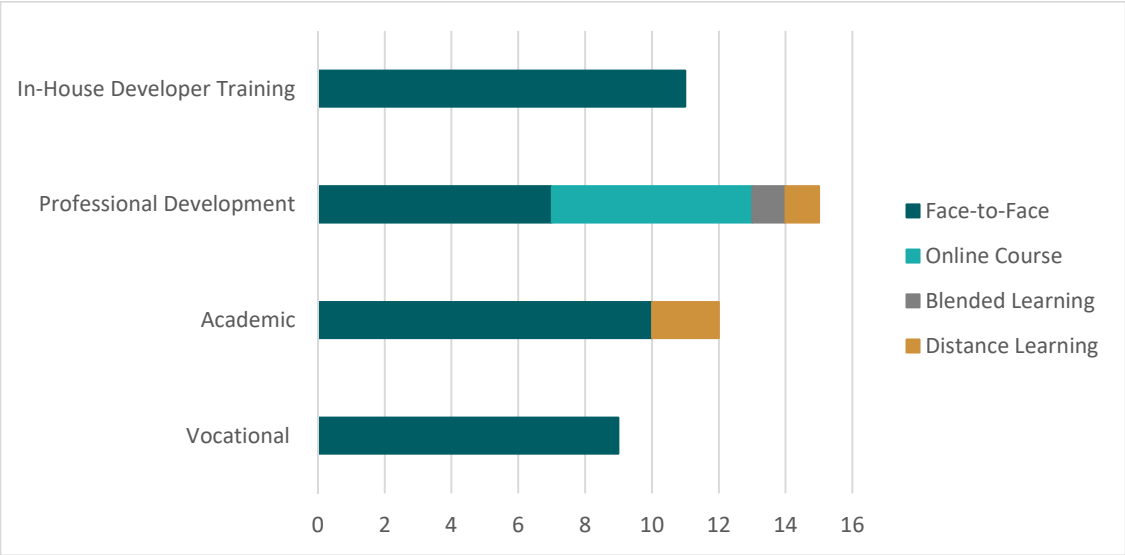
Most of the training today is done face-to-face[5] or on-the-job rather than online[6] or through distance learning. As the chart below shows, most of the 36 external training programmes reviewed use the face-to-face approach, with only six using online (all professional development courses) and just three using distance learning (two academic courses and one professional development course). In addition to the external training programmes, most mini-grid operators run their own on-the-job training – all 11 of the developers interviewed had their own training programmes. Despite this, most developers say they would prefer, if affordable, to outsource training to a qualified local institution, ideally one located close to their mini-grids.

Some professional development training providers use a blend of face-to-face and online training which allows for more flexibility in terms of when, where and how different types of training are done. For example, training on theoretical topics can be done remotely or online, while practical work is better suited for the classroom or the field. The blended approach helps the training providers to keep their costs down and widen the audience of potential students. The success of such an approach, however, depends on students having internet connectivity and access to computers.

[5] Face-to-face training includes classroom training, seminars, roundtables, group exercises, workshops, assessments, field trips or on-the-job

[6] Online training includes e-learning, virtual meetings and webinars. Some training providers are experimenting with mobile content and applications.

Number of training programmes reviewed broken down by programme type and delivery model used



C4. Certification

There is currently no widely recognized mini-grid industry training standard. While nearly all vocational courses are locally certified, professional development courses are often not certified and there is no regional certification system for mini-grid training.

Everyone agrees on the importance of certifying mini-grid courses and accrediting local training providers – it improves and standardises the quality of training and allows for wider delivery of courses through accredited local training institutions.

However, there is still no clear path on how this certification should be done. One idea is to create nationally recognized mini-grid certificates similar to the ones for solar engineers. Another is to introduce regional as well as national certificates, although this assumes the relevant national institutions can agree on common quality standards. Another option is to create regional training programmes which can be delivered through a common platform and integrated through local certification or standardised tests.

C5. Views of developers and training providers

Developers have broadly similar views about the kind of training they want:

- They prefer shorter, practical or field-based courses lasting a few weeks or months over courses lasting several years.
- They prefer professional development and vocational training courses which address particular skills gaps over academic courses.
- They find face-to-face training more effective than online or distant learning.
- They prefer training courses and providers to be accredited by local authorities to ensure consistent high quality.
- They like training that is tailored for the local context and implemented by local training institutions.
- They would like to increase the opportunities for peer-to-peer learning.

- They would like training courses to be developed that are targeted at different types of developer (early stage versus operational, international versus local).
- They want training providers to collaborate more closely with the industry in the development and delivery of training programmes.

The training providers highlighted other areas for making training more effective and sustainable:

- They stressed the importance of not training developers in isolation. Other mini-grid stakeholders such as policy makers, end-users, and financiers also need training in order to facilitate development of the mini-grid ecosystem and improve communication between different stakeholders.
- They highlighted the organisational and logistical challenges of delivering mini-grid training at scale, including local language and cultural issues.
- Some of the current training programmes are provided free at the point-of-use. This is not sustainable and it will be important to find ways of making training programmes viable for both developers and training providers e.g. charging affordable fees to developers and offering scholarships; keeping costs down through increased use of online, mobile and distance learning tools; corporate sponsorships; public-private partnerships etc.

D. Review of training providers

Through interviews and desktop research, we have analysed 53 existing and potential mini-grid training providers and identified some organisations and partnerships that could potentially deliver mini-grid training in new areas.

We have considered two main types of training provider:

- *Implementers* that deliver the training. We have mainly focused on accredited local organisations that offer face-to-face training; and
- *Facilitators* that provide funding or other support to the implementers e.g. design of training materials, free equipment for hands-on training, and facilitating regional certification. These facilitators include donors, large corporates, NGOs, and TA providers.

We have assessed the training providers against four key criteria:

- *Experience* in delivering certified renewable energy or mini-grid training in Africa;
- *Availability of resources* such as personnel, infrastructure and funding to ensure continuity and sustainability of training;
- *Commitment* to mini-grid specific training; and
- *Geographical coverage*. Note most of the current implementers operate only in one country, although some have plans to expand regionally. We have therefore focused on those providers operating in the more developed or high potential mini-grid markets.

Below we provide short descriptions of some of the more interesting training providers and the countries in which they operate:

Implementers

- *Micro-Grid Academy, RES4Africa, Kenya Power Training School and University of Strathmore (Kenya, in the future East Africa and Southern Africa)* – RES4Africa[7] has established the Micro-Grid Academy in Kenya together with local partners including the Institute of Energy Studies and Research (or **IESR,** formerly the Kenya Power Training School), the University of Strathmore, St Kizito Vocational Training Institute, and AVSI, a non-governmental organization. IESR is recognised as a centre of excellence under the African Network of Centres of Excellence in Electricity (**ANCEE**). The Academy's first two weekly training courses for energy professionals took place in January and April 2018 and a third is planned in October 2018. Students will soon be able to get hands-on experience from an operating 30 kW solar mini-grid which is being built on the site of Kenya Power. While the main focus today is more on the technical side, the Academy is planning to develop a complete mini-grid training curriculum later this year and aims to eventually train 300-500 East African students a year. It is also planning to launch courses in Zambia in November 2018 and in South Africa next year.

- *KIITEC (Tanzania)* – The Kilimanjaro International Institute for Telecommunications, Electronics and Computers is an accredited technical training institute based in Arusha in northern Tanzania which offers certified courses for electrical engineers. Their approach to learning is 70% practical and 30% theoretical. Their courses include a three year diploma, professional development courses of one to three months and vocational training courses of 30-60 hours. They are also now developing a six month professional development course for solar mini-grid installers, operators and site managers, with support from Schneider Electric.

- *NAPTIN (Nigeria and West Africa)* - The National Power Training Institute in Nigeria has worked with GIZ under the Nigerian Energy Support Program to design and deliver certified technical training courses on solar PV, micro-hydro and mini-grids to technicians and engineers. NAPTIN is recognised as a centre of excellence under ANCEE and has recently started collaborating with the Association of Power Utilities of Africa (**APUA –** see list of facilitators below) to deliver training to about 500 electricity professionals from Ghana and Benin through APUA's scholarship scheme.

- *CREEC (Uganda)* – The Centre for Research in Energy and Energy Conservation is a part of Makerere University in Kampala and focuses on rural electrification, productive use of energy and energy entrepreneurship. They have experience in designing, building and operating their own solar PV mini-grid system in central Uganda for research purposes.

- *Miller Centre for Social Entrepreneurship* – The Miller Centre is a social enterprise accelerator based out of Santa Clara University in California in America. They are planning to develop a module-based mini-grid training programme for Africa focused on enterprise incubation, industry best practice, practical training based around real life mini-grid case studies and including mentoring from Silicon Valley entrepreneurs. They have already done something similar for last mile distribution in Africa.

- *SELCO Foundation* – The SELCO Foundation is a social enterprise based in India with extensive experience of hands-on capacity building and development of locally owned and managed

[7] RES4Africa is a network of over 30 members from across the sustainable energy value chain including utilities such as ENEL, industries, agencies, technical service providers, research institutes and academia. University of Sapienza Rome is a member and has played an important role in the setting up of the Academy.

energy enterprises (including mini-grids). They plan to bring their capacity building model to mini-grids in Africa, starting in Tanzania in partnership with the Don Bosco Technical Training Institute.

Facilitators

- *APUA (all SSA)* - APUA[8] is an international non-governmental association headquartered in Côte d'Ivoire which promotes the development of the African electrical sector. APUA has 56 active members from 46 African countries and includes 16 African power utilities. One of APUA's flagship programmes is the African Network of Centers of Excellence in Electricity (ANCEE), which is centred on capacity development and knowledge sharing and has been funded by the AFD (French Development Agency) and the AfDB. We have identified two training centres from ANCEE that are particularly well qualified to act as mini-grid training implementing partners in SSA, namely IESR and NAPTIN described above.

- *GIZ (Nigeria, Kenya, Uganda)* – Gesellschaft für Internationale Zusammenarbeit, a German government development agency, has developed mini-grid training programmes in Nigeria (see NAPTIN above in the list of implementers), Kenya and Uganda. In Kenya they have developed a training course together with Strathmore University for solar technicians which certifies them to install solar-hybrid village systems of up to 10 kWp. In Uganda they established a model mini-grid in Kampala for the purpose of on-the-job training of around 200 mini-grid technicians.

- *Schneider Electric Foundation (all SSA)* – Schneider Electric Foundation has its own technical, vocational and entrepreneurship training programmes which support skills development in electricity-related fields (not just mini-grids). They do not usually offer the training themselves. Instead they help develop training for local vocational training institutions, including government organisations, technical universities, faith organisations and other NGOs. They also train the trainers and fund investments in electrical equipment and didactic benches for hands-on and practical training. The Foundation currently has 46 training partners in SSA.

- *ECREEE* – The ECOWAS Centre for Renewable Energy and Energy Efficiency (**ECREEE**) is a centre of excellence for the Economic Community for West African States (**ECOWAS**) and has a mandate to promote regional renewable energy and energy efficiency markets. They are in the process of establishing a Regional Certification Scheme (RCS) for renewable energy in the ECOWAS region, starting off with a pilot for solar PV installers. They have identified 21 training institutions in 8 countries to participate in the pilot phase and are working together with IRENA, GIZ and the West African Economic and Monetary Union (UEMOA). ECREEE also occasionally run training workshops on mini-grids, but these are mainly for policy makers rather than developers.

- *Other organisations e.g. ALER, ESMAP* – There are a number of other public organisations that arrange one-off mini-grid training workshops and events in Africa. These organisations include Associacao Lusofona de Energias Renovaveis (**ALER**), which covers Portuguese speaking countries, and the World Bank's Energy Sector Management Assistance Program (**ESMAP**). The events they organise tend to run over a few days and focus more on mini-grid policy and regulations, but they are not specifically geared towards developers.

[8] Also known Association des Sociétés d'Electricité d'Afrique (ASEA)

- *ECA* - Economic Consulting Associates Ltd (**ECA**) is writing a report on the training needs of mini-grid *financiers*. This work has also been commissioned by the AfDB. As with the Help Desk, ECA will prepare a mini-grid curriculum for financiers and provide training of trainers.

E. Recommendations

Our main recommendations for mini-grid training in SSA are:

- Fill the gaps in the mini-grid curriculum content, particularly on business and financing, policy and regulation, health and safety, ICT and certain technical and engineering topics.
- Focus on short, practical, face-to-face vocational and professional development training courses which address particular skills needs and include field work and peer-to-peer learning between developers and other stakeholders.
- Certify more mini-grid courses, particularly professional development courses, to improve and standardise training quality and allow for wider implementation through nationally accredited local training centres. If possible, introduce regional as well as local certification.
- Build the resources and capacity of select local and regional training implementing organisations. This support might include helping design new course materials, investing in equipment and demo sites for hands-on training, testing new training delivery methods, and training the trainers.

The Help Desk will contribute to the above by developing training materials over the next 15 months to address some of the curriculum gaps and by working closely with and training trainers from some of the training providers mentioned in this report.

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1. Introduction

1.1 Background

The market for private investment in mini-grids is still relatively immature, and this is reflected in the lack of skills and experience of developers and local project staff. The same applies to other mini-grid stakeholders, including policy makers, regulators and financiers. There is a lack of mini-grid specific training courses and dedicated local training centres. Training and technical assistance (**TA**) more broadly is therefore critical if mini-grids are to be scaled up.

This report has been produced by Energy 4 Impact and Inensus (the **Help Desk**) under the Green Mini-Grid Market Development Programme for the African Development Bank (**AfDB**) - Business Development Services and Policy Support Business Lines.

The report specifically assesses the training needs of mini-grid *developers* in Sub Saharan Africa (**SSA**). It is the first of three training deliverables assigned to the Help Desk, the others being development of a mini-grid curriculum for developers and training of trainers.

This report should be read alongside a report being written by ECA Economic Consulting Associates Ltd (**ECA**) which looks at the training needs of mini-grid *financiers*. This work has also been commissioned by the AfDB, this time through the Access to Finance Business Line. Just like the Help Desk, ECA will prepare a mini-grid curriculum for financiers and provide training of trainers.

1.2 Purpose and scope

This main purpose of this report is to identify the knowledge and skills requirements of mini-grid developers and evaluate whether these requirements are being addressed by existing training programmes. It maps all the training programmes, focusing on their content and method of delivery, and recommends what future training programmes should focus on and which existing training organisations might be good implementing partners.

The report is targeted at *private developers* of green mini-grids in SSA. A green mini-grid is a set of small-scale electricity generators and possibly energy storage systems connected to a distribution network that supplies electricity to a small, localised group of customers and operates independently from the national transmission grid. They can run on renewables (solar PV, hydro, wind, and biomass) or as renewable-diesel hybrids.

The report focuses mainly on *solar developers* with projects ranging in size from a few kilowatts to tens or hundreds of kilowatts, simply because these are the most common category of developer. Other renewable technologies and larger projects are also considered, but they are not the main focus of this report.

1.3 Definitions

The report focusses on “training” and “capacity building” rather than the wider topic of “technical assistance”.

For the purposes of this report:

- *TA* is non-financial assistance in the form of consultancy, knowledge sharing and other skills transfer. It often includes hands-on support for developers to meet specific milestones or address certain challenges – this is the primary role of the Green Mini-grids Help Desk. Training and capacity building can be considered as sub-categories of TA.
- *Capacity building* is the process of optimising skills of environments/sectors, organisations/ institutions and individuals. It relies on flexibility and tailored approaches to developing skills.
- *Training* is targeted at specific groups of individuals and is often geared towards acquiring specific skills and competencies to carry out certain activities or tasks. Training is typically

associated with taking a course and some form of assessment or examination to test knowledge and skills. The four main types of training – vocational, professional development, academic and developer trainings on-the-job – are described in more detail later in the report.

1.4 Methodology

This report is based on five main sources of information:

- Interviews with 11 mini-grid developers operating across 12 countries and AMDA, the Africa Mini-grid Developers Association;
- Interviews with 20 training or knowledge providers (including international donors, large energy companies, government training centres, private training providers, universities and research institutes, and incubators) and desktop research on another 33 training providers;
- Reviews of 36 vocational, professional development or academic training programmes and 11 on-the-job informal training programmes run by developers themselves; and
- Experience of Energy 4 Impact and Inensus as providers of TA to over 100 developers.

1.5 Audience

The report was produced for the AfDB to inform development of a mini-grid training curriculum, but is freely available to all interested parties.

1.6 Contact information

For more information on the report, please contact Peter Weston on peter.weston@energy4impact.org or Mercy Rose on mercy.rose@energy4impact.org.

2. Requirements of developers

This section looks at the training requirements of developers, the factors influencing those requirements, and how those requirements can be addressed by a training programme or training provider.

As part of our research, we interviewed the African Mini-grid Developers' Association (AMDA) and the 11 developers listed in Table 1.

Table 1: Developers interviewed

Developer name	Type of mini-grid	Country of operations	Stage of development	Type of developer
Absolute Energy	Solar	Uganda	Operational	International
Africa GreenTec	Solar	Mali/Niger	Operational	International
Eco Gardens	Hydro	Uganda	Operational	Local
Energy Kiosks	Solar	Togo/Benin	Operational	International
FlexGrid	Solar	Mali	Operational	International
Husk Power	Solar / Biomass	Tanzania	Operational	International
PowerGen	Solar	Kenya/Tanzania	Operational	International
PowerNed	Hydro	Sierra Leone	Operational	International
RVE Sol	Solar	Kenya	Operational	International
Samaritan Touch	Solar	Nigeria	Early stage	Local
Zahra Energy	Solar	Nigeria	Early stage	Local

Many developers lack the skills, knowledge and experience to develop and run mini-grids properly and require training in different areas. Mini-grid training may be divided into five subject matter categories (see Section 2.1). The actual training required depends on the type and background of the developer, how advanced they are with their projects, and the nature of the staff being trained (see Section 2.2). Developers face many common challenges (see Section 2.3) and are broadly aligned on what they want from training programmes (see Section 2.4 and 3.5).

2.1 Subject matter categories

A comprehensive mini-grid training curriculum should aim to cover the whole project life cycle from project development and construction through to operation:

- *Project development* – site selection, demand assessment, technical system design and system sizing, distribution network mapping, business models, financial modelling, feasibility studies, capital raising, and project management.
- *Construction* – contracting, procurement, installation, commissioning, capital raising and financing, and project management.
- *Operations and maintenance* – O&M management and process software, marketing and sales, tariff setting, customer service, metering, demand side management, demand stimulation including micro-enterprise development, performance monitoring and evaluation, and enterprise management.

There are five main subject matter categories for mini-grid training:

- *Technical;*
- *Financial;*
- *Business management;*

- *Legal, regulatory compliance and contracting; and*
- *Core skills* e.g. financial modelling, project management, risk assessment, proposal writing.

Table 2 describes the subject matter categories in more detail and shows how they apply to the different stages in the mini-grid project development life cycle.

Table 2: Training topics across mini-grid project life cycle

	Early stage: Project development	**Middle stage: Construction**	**Late stage: Operations and maintenance**
Technical	• Site identification • Demand assessment • System design and sizing • Prefeasibility/Feasibility Study • Distribution network mapping and installation • Grid planning	• Solar system installation • Selection of batteries/inverters • Meter installation • Distribution: Electrical connections and house wiring • Quality control • Occupational safety	• Grid/ load management • Maintenance of the plant
Business	• Tariff setting and structuring • Marketing and after sales customer service • Proposal writing • Business modelling • Customer identification/ selection • Demand stimulation / promoting productive use of electricity • Community engagement	• Project management	• Demand Stimulation • Business performance monitoring and evaluation (data analytics)
Financial	• Financial modelling • Capital raising	• Accounting	• Financial reporting • Cash flow management • Billing • Consumer finance
Legal, regulatory compliance and contracting	• Company set-up • Environmental and social impact assessments • Licensing and approvals • Land agreements	• Contracting with EPC/suppliers • Procurement procedures • Import/export	• Tariff approvals • Taxation • Quality of service regulations • Technical regulations (generation and distribution, and metering) • Health and safety regulations • Customer contracts • Public-private partnerships
Core skills	• Project management • Financial modelling • Risk assessment • Health and safety • Proposal writing	• Project management • Financial modelling • Risk assessment • Health and safety • Proposal writing	• Enterprise management • Financial modelling • Risk assessment • Health and safety • Proposal writing

2.2 Differences between developers

Where possible, mini-grid training should be adapted according to the type and experience of the developer and the level of seniority and responsibilities of staff members. The training required can vary a lot according to the size of the developer, the technology of their mini-grids, whether they are international or local, whether they are a single country or regional player, and whether they are early stage and inexperienced or have operational plants. We elaborate on some of these ideas below:

- *Size and experience of developer* - Larger, more experienced developers tend to be more interested in targeted training support. Smaller, newer developers with little or no mini-grid experience tend to have more demand for class-room based training which covers all aspects of mini-grids. The size and level of advancement of the developer will also dictate the type of training required around specific issues such as access to capital (start-up versus growth capital) and procurement of equipment (single versus bulk purchasing).
- *International versus and local* - International developers usually have better access to technologies, knowledge networks and private and public capital than their local counterparts. The international players are more able to bring skills and experience from related sectors such as renewable energy, telecoms and finance. However, many lack experience working in rural Africa, so require support on local customs, standards, policies and regulations. Local developers, in contrast, know how things work on the ground, but do not necessarily have the required technical, engineering, commercial and financing skills.
- *Staff role* - The top management of developers need to have a good understanding of the overall business, including business models, regulations, financing and staff management, while field staff must run the mini-grid operations effectively from a commercial, technical, and customer management and payment perspective.

2.3 Common developer challenges

There are a number of challenges that apply to all developers. The most common complaints relate to the shortage of skilled staff in remote, rural areas, particularly in the following areas:

- *Project managers;*
- *Sales and after sales staff;*
- *Certified electrical engineers and technicians;*
- *Occupational health and safety experts; and*
- *IT and communications staff.*

It is not just an issue of finding skilled staff. Even when they can be found, developers often have to pay a premium to bring them from the cities to rural areas and they also face difficulties around staff retention. In some countries, such as Mali and Niger, it is hard even to find qualified engineers in the cities.

Skills, knowledge and experience are particularly in short supply in the following areas:

- *Technical and engineering* e.g. demand assessment and forecasting, system design and sizing, distribution network mapping, technical feasibility studies, procurement and contracting, installation and commissioning, technical operations and maintenance, technical demand side management, and metering;
- *Commercial* e.g. feasibility studies and business plans, tariff setting, billing, demand stimulation, marketing, customer service, and community engagement;
- *Policy, legal and regulatory* e.g. local mini-grid regulations, licences and permits, other technical, environmental, health and safety, financial and fiscal regulations and standards; and
- *Financing* e.g. financial modelling, capital raising and proposal writing.

2.4 Conclusions

Developers say many of the existing training programmes do not meet their requirements. They prefer courses that are short and practical, target specific skills gaps, and are carried out close to their mini-grids. They complain that courses are often too generic and not mini-grid specific enough. Most of the technical courses are for solar engineers rather than other renewable technologies. Much of the training is available only in urban centres and getting to the city from rural areas is costly and time consuming. Please see Section 3.5.1 for more information on the views of developers.

3. Existing training programmes

This section reviews the main mini-grid training programmes, looks at the different types of training provider and programme, and comments on their content, method of delivery, and accreditation or certification status. It provides information on the existing programmes and feedback on what developers would like to see from future programmes.

Training programmes tend to fall into one of four categories: vocational, professional development, academic or on-the-job. There are many renewable energy training programmes in Africa and globally, but very few are specific to mini-grids or developers. The few programmes that do exist are relatively new and are mainly vocational or professional development programmes implemented by African institutions and funded by international organisations.

Most programmes have a fairly narrow focus on technical training for engineers and do not adequately cover other mini-grid topics. This is partly because, apart from mini-grid technology and policy, there are no commonly agreed best practices for developing, constructing and operating mini-grids. Training on local mini-grid regulations is also lacking and this is probably a reflection of the lack of clarity and transparency around mini-grid regulations in most African countries.

We have identified shortcomings in both the content of and method of delivery used by the training programmes. Some training providers are aware of those shortcomings and, where funding is available, are trying to address them by re-designing their programme or designing new ones.

3.1 Types of training programme

There are four main types of training programme:

- *Vocational* – these focus on the practical skills and knowledge required to perform a particular job or task. They usually last several weeks or months and target informal, formal and semi-skilled individuals who want to enter the market or are already active but at an entry level and with lower professional qualifications (e.g. electricians). They tend to be more technical/engineering focused and are usually locally certified and delivered by accredited local training institutions. We reviewed nine of these programmes (see Section 3.1.1 below).
- *Professional development* – these are a specialised form of training for individuals that are already in a certain career or job and often include formal and more advanced education. They target more skilled professionals with a formal education background (e.g. engineers) and equip them with professional knowledge and qualifications. They can last several weeks or months. In the renewable energy and mini-grid sector most professional training providers are technical/engineering focused. Their programmes are not necessarily certified, so their courses are less standardised. We reviewed 15 of these programmes (see Section 3.1.2 below).
- *Academic* – these are more focused on research and academic training in a certain field of study than practical experience. The courses are run by schools, universities and training institutions. They usually last one to three years and the student receives a degree, diploma or equivalent qualification. They are rarely mini-grid specific but may include mini-grid components as part of a broader curriculum such as renewable energy. We reviewed 12 of these programmes (see Section 3.1.3 below).
- *On-the-job* – these trainings are organised by the developers themselves. They are generally informal and often done in the field and designed for field engineers. Some developers are trying to develop more formalised training with manuals etc. Others are bringing staff to their home countries for training, while a third group are using external experts to run adhoc training in the field. A detailed analysis of the developers' on-the-job programmes is beyond

the scope of this report. However, all 11 of the developers we interviewed, including the early stage developers, have such programmes.

In addition to the above, there are several interesting internship programmes, which help develop skills by placing skilled staff in mini-grid developers. The Carnegie Mellon - Rwanda University is a good example of such a programme, while the next phase of the DFID-funded TEA Programme will also promote internships in mini-grid developers. Finally, it is worth highlighting that there are many useful online mini-grid tools and resources which can be integrated into current or future programmes (see Section 3.1.4).

3.1.1 Vocational training programmes

We reviewed the nine vocational training programmes listed in Table 3.

Table 3: Vocational programmes reviewed

Name of programme	Name of providers	Location of provider	Duration	Method of delivery
Solar PV installation	National Power Training Institute (NAPTIN)	Nigeria	20 days	Face-to-face
Supervising Solar PV installation	NAPTIN	Nigeria	30 days	Face-to-face
Solar PV training - beginner	Strathmore University, Nairobi and local partners	Kenya	20 days	Blended – face-to-face and online
Solar PV training – intermediate	Strathmore University, Nairobi and local partners	Kenya	20 days	Blended – face-to-face and online
Solar PV systems for designers and installers	Kilimanjaro International Institute for Telecommunications, Electronics and Computers (KIITEC)	Tanzania	1 month	Face-to-face
Domestic electrical and solar PV installation	KIITEC	Tanzania	6 months	Face-to-face
Solar Technician Training Course	Makerere University – CREEC Centre	Uganda	5 days	Face-to-face
Solar Testing Course	Makerere University – CREEC Centre	Uganda	5 days	Face-to-face
Pico/Micro-hydro Design and Installation	Makerere University – CREEC Centre	Uganda	5 days	Face-to-face

All vocational programmes follow a specific set of national certification and accreditation standards. This allows them to be carried out by multiple local training institutions provided they are accredited by the relevant national authorities.

We have not come across any region-wide vocational training programme. The programmes listed are only certified in their respective country, which reflects the differences in vocational training standards between countries.

Most of the programmes are targeted at the energy industry in general (e.g. certification of electricians and other technicians), rather than being mini-grids-specific.

We have not identified any mini-grid specific vocational programmes in southern Africa, although the Micro-Grid Academy is planning courses in Zambia and South Africa.

3.1.2 Professional development training programmes

We reviewed the 15 professional development training programmes listed in Table 4, some of which are held regularly and others which are one-offs.

Table 4: Professional development programmes reviewed

Name of programme	Name of provider	Location of provider	Duration	Method of delivery	Certificate awarded
Renewable Energy Project Developer	Renewables Academy	Germany	6 months	Face-to-face	Yes
Photovoltaic Professional	Renewables Academy	Germany	6 months	Online	Yes
Solar energy seminar series	Renewables Academy and Oasis Solar Academy Egypt	Germany and Egypt	Variable duration	Seminar/short course for solar stakeholders in Egypt	Yes
Renewable energy focused bespoke training	Renewables Academy	Germany	Variable duration	Seminar/short course for any renewable energy sector stakeholder in any country	No
Workshop on solar-diesel hybrid mini-grids	Renewables Academy for Kenya Power and Kenya Rural Electrification Authority	Germany and Kenya	Under 1 week	Face-to-face	No
Off Grid Renewable Energy Systems	Engerati – a network of European utilities and power sector stakeholders	UK	8 weeks	Online	No
Mini-grid Design course	National Power Training Institute (NAPTIN)	Nigeria	5 weeks	Face-to-face	Yes
Solar hybrid training	Strathmore University Kenya and University of Nairobi	Kenya	3 weeks	Blended - online and face-to-face	Yes

Renewable Energy for Sustainable Development	University of Strathclyde	UK	8 weeks	Online	Yes
Solar PV systems for designers and installers	Kilimanjaro International Institute for Telecommunications, Electronics and Computers (KIITEC)	Tanzania	1 month	Face-to-face	Yes
Clean Energy Project Analysis for trainers	ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)	Cape Verde	2-3 days	Online	No
Mechanical Engineering – Sustainable Energy Certification	Columbia University	USA	Less than 2 years	Online	Yes
Certification of Professional Achievement in Data Sciences	Columbia University	USA	Less than 2 years	Online	Yes
Renewable Energy Certificate	Santa Clara University, California	USA	Up to 1 year	Face-to-face	Yes
Renewable Energy short courses	University of Loughborough	UK	Up to 3 months	Face-to-face/ Distance learning	Yes

Professional development courses are offered by a mix of local and international providers, including academic institutions, technical training institutions and technical assistance providers. The courses typically last between a few days and six months.

Students on professional development training programmes do not always get certificates for completing the course. However, 11 of the programmes we reviewed did issue certificates.

Most professional development courses are carried out face-to-face in the class room, although some also use webinars and distance learning.

Some of the courses are targeted at quite wide audiences, including policy makers, regulators and financiers, as well as developers and other electricity industry technicians.

3.1.3 Academic training programmes

We reviewed the 12 academic programmes listed in Table 5. Given the large number of renewable energy degrees around the world, this report has concentrated on postgraduate master's degrees rather than standard undergraduate degrees.

Table 5: Academic programmes reviewed

Name of master's programme	Name of provider	Location of provider	Duration	Method of delivery	Geographical classification
MBA in Renewables	Renewables Academy	Germany	30 months	Distance learning	International
MSc or MA in Energy and Resources[9]	University of California Berkeley	USA	24 months	Face-to-face	International
MSc in Renewable Energy Systems Technology	Loughborough University	UK	12-36 months	Face-to-face/Distance learning	International
MSc in Electrical and Computer Engineering	Carnegie Mellon University, Kigali campus	Rwanda	Up to 16 months	Face-to-face	Hybrid – international and Africa
MSc in Sustainable Engineering: Renewable Energy Systems and the Environment	University of Strathclyde	UK	12 months	Face-to-face	International
MSc in Sustainable Energy[10]	National University of Lesotho	Lesotho	12 months	Face-to-face	Africa
MSc in Renewable Energy[11]	University of Zimbabwe	Zimbabwe	Under development – to be confirmed	Face-to-face	Africa
MSc in Energy and Sustainability with Electrical Power Engineering	Southampton University	UK	12 months	Face-to-face	International
MSc in Renewable Energy	Makerere University	Uganda	24 months	Face-to-face	Africa
MSc in Sustainable Energy Futures	Imperial College London	UK	12 months	Face-to-face	International
MSc in Power Systems and Sustainable Energy	Santa Clara University, California	USA	24 months	Face-to-face	International
MSc(Eng) in Sustainable Energy Engineering	University of Cape Town	South Africa	24 months	Face-to-face	Africa

[9] Includes micro-grids and energy access elective
[10] EUEI PDF's RECP Programme provided support between February 2017 and February 2018.
[11] EUEI PDF's RECP Programme provided support between July 2015 and March 2018.

Most of the academic programmes we reviewed relate to renewable energy and energy resource management. They tend not to be mini-grid specific, although some include mini-grids as a course module or support student research on mini-grids.

Most of the masters courses are quite technical, with students learning about computer modelling programmes to analyse, design and monitor renewable energy systems. Many of them also include training on financing, energy economics, and sustainability and policy studies.

While academic courses may not be mini-grid specific, we observe a growing interest in mini-grids by universities through their research work. Several universities have either developed their own mini-grids or are carrying out on-the-ground mini-grid research work in collaboration with local partners, in a bid to improve their learning and to give their students more hands-on experience:

- Colorado State University has an alliance with MeshPower, a mini-grid developer in Rwanda, and is installing new micro-grids in the country to test new models for productive use. Other international universities that have developed their own mini-grids include Southampton University (6 mini-grids in Kenya, Uganda and Cameroon) and University of Notre Dame (Uganda). Local African universities involved in mini-grid development include Makerere University (Uganda), Strathmore University (Kenya) and St Augustine University (a minority investor in Jumeme's mini-grids in Tanzania).
- Duke University, Carnegie Mellon University and University of Massachusetts at Amherst are carrying out impact studies of mini-grid prototypes implemented by the Minigrid Innovation Lab in east and west Africa. The Innovation Lab is a Rockefeller-funded initiative that is being implemented by Crossboundary and Energy 4 Impact. Carnegie Mellon is also placing interns in mini-grid developers through its Rwanda campus.
- Imperial College London is leading a programme which aims is to understand how small scale generation, mini-grids and a large national/regional electricity grid can work together to improve access to electricity. The project includes academic and commercial partners from Rwanda (African Center of Excellence in Energy for Sustainable Development at the University of Rwanda, plus Meshpower and Bboxx) and Nepal.
- Other universities active in mini-grids and energy access research include Columbia University (working with Absolute Energy in Uganda), University of Berkeley California, the Laboratory for Energy And Power Solutions at Arizona State University, Santa Clara University (together with the Miller Centre), Strathclyde University (Malawi), Leicester University (Uganda), University of Sussex, University of Loughborough and the Energy Research Centre of the University of Cape Town.

3.1.4 Other tools and resources

There is a wide range of useful online mini-grid tools and resources which can be integrated into training programmes. They include software, desktop and web-based tools for developing and operating mini-grid projects and information resources such as manuals and websites. We list below some of the more useful tools and resources:

- AfDB's Green Mini-Grid Help Desk website[12];
- Acumen's Energy Impact Series and Lean Data Program[13];

[12] https://greenmini-grid.se4all-africa.org/
[13] https://acumen.org/lean-data

- EUEI PDF's Retail Tariff Toolbox[14] and Renewable Energy Tariff Toolbox[15];
- GIZ's Mini-grid Builder[16];
- HOMER software for mini-grid system design and optimization[17];
- Other PV simulation software e.g. PVsyst and PV*Sol[18];
- NREL's Mini-grid Quality Assurance Framework and Implementation Guide, plus other mini-grid guides on tariffs, productive use and customer agreements[19];
- Odyssey Energy Solutions[20]; and
- RECP's Mini-grid Policy Toolkit[21]

Most of these tools and resources are open source and therefore available for free (HOMER is an exception). While formal training is not necessary for many of these tools, it will help improve the user experience and increase uptake and awareness of the tools. Incorporating the tools into established training programmes will also provide a window for those developing the tools to train more people and get user feedback to make improvements.

[14] http://www.euei-pdf.org/en/recp/supportive-framework-conditions-for-green-mini-grids

[15] http://www.euei-pdf.org/en/seads/capacity-building/renewable-energy-tariff-calculation-toolbox-for-ecowas

[16] https://www.mini-gridbuilder.com/. GIZ's web-based tool allows solar PV mini-grid developers to estimate electricity demand based on site data. It also provides basic financial information to help developers make informed decisions on project implementation.

[17] https://www.homerenergy.com/ HOMER is the most widely used industry software for mini-grid system design and optimization. Training is recommended prior to using this tool. Many academic and technical professional development courses reviewed above utilise HOMER in their training. However, HOMER Energy - the company that develops and distributes the software - is the only one that offers certified training on the software.

[18] http://www.pvsyst.com/en/ and https://www.solardesign.co.uk/pvsol.php

[19] https://www.nrel.gov/docs/fy17osti/67374.pdf and https://www.nrel.gov/docs/fy17osti/68634.pdf and https://cleanenergysolutions.org/qaf

[20] https://www.odysseyenergysolutions.com/ Odyssey's online platform helps mini-grid project developers to design, build and operate data-driven micro-grids. It provides support on site assessments, load forecasts, system design, tariff design, financial modelling and performance monitoring. It is integrated with external tools such as HOMER and can also help developers on procuring equipment and access to financing.

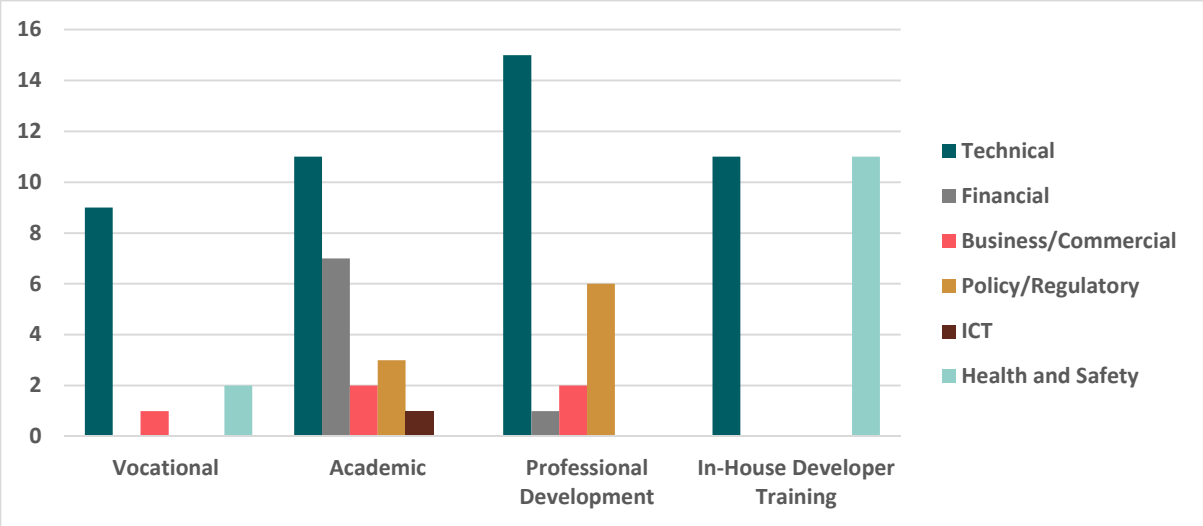
[21] http://www.euei-pdf.org/en/recp/mini-grid-policy-toolkit

3.2 Training content

In this section, we review the content of the training programmes mentioned in Section 3.1.

Figure 1 summarises the type of content covered by the different categories of training programme. It shows that technical/engineering content is well covered across all programmes, while business/financial/policy topics are covered in some professional development and academic programmes. Health and safety is covered in all the in-house developer programmes and a few vocational training programmes, while information and communication technology (ICT)[22] is barely covered at all.

Figure 1: Content offered by different types of training programmes (numbers are based on training programmes reviewed)



The focus on technical/engineering training may be partly explained by the fact that there are no commonly agreed best practices for most mini-grid areas e.g. development, construction and installation, operations etc.

In Table 6 we look in detail at the different types of mini-grid training content and the gaps in the current training programmes. Our main findings are that:

- Certain topics are not covered well by existing training courses. These include: mini-grid business models, capital raising, tariff setting, technical system sizing and distribution grid design, local policies and regulations, health and safety, operations management and process software, and performance monitoring and evaluation.
- Many developers are missing core skills such as project management, financial modelling, risk assessment and proposal writing.
- Most of the training programmes for mini-grids are focused on solar technologies, particularly solar engineering.

[22] Covers data analytics and performance monitoring, especially during the operational phase of a mini-grid

Table 6: Gaps in training content

Training content	Demand for training from developers	Current training provision	Gaps in training content
Business / finance	Mini-grid business models Feasibility studies Capital raising and financing Tariff setting and structuring Billing and metering Demand stimulation Marketing and after sales service Community and stakeholder engagement Financial modelling and reporting	*Partly covered*: Mini-grid business models Capital raising and financing e.g. sources of capital, project financing Tariff models Marketing and sales Community and stakeholder engagement Financial reporting	Mini-grid business and financial models Feasibility studies Capital raising. corporate finance, asset finance, end user finance Tariff setting and structuring Billing and metering Demand stimulation, especially with productive users Marketing, customer agreements and after sales customer service Community and stakeholder engagement
Policy / legal/ regulatory	Local mini-grid policy and regulations Local licensing and approval processes Local procurement rules Local technical standards	*Partly covered*: High level mini-grid policy & regulation, energy planning	Local mini-grid policy and regulations.[23] Local licensing and approval processes Local procurement rules Local technical standards
Technical / engineering	Site selection Demand assessment / forecasting Technical system design for generation and grid, including system sizing Procurement and contracting Installation and commissioning Operations	*Adequately covered*: Renewable resource assessment Generation system design Overview of renewable technologies Design simulation *Partly covered*: Site selection Demand assessment Load analysis Installation and commissioning	Demand assessment and forecasting techniques System design and sizing, especially distribution grid design and mapping Procurement and contracting Installation and commissioning Operations & maintenance, including operational management Customer connections, household installations and wiring Demand-side management and end user electrical appliances Remote monitoring and metering

[23] The lack of suitable training in this area may partly be explained by the lack of clarity and transparency around mini-grid regulations in many African countries.

Health & safety	Health & safety for mini-grid staff Health and safety for end users	*Not properly addressed*	Health & safety for mini-grid staff Health and safety for end users
Information and communication technology (ICT)	Performance monitoring and evaluation Operation and maintenance (O&M) process software[24]	*Partly covered:* Impact assessment	Data analytics, especially for evaluation of operational performance O&M process software
Core skills	Project and enterprise management Financial modelling Risk assessment and mitigation	*Not properly addressed*	Project and enterprise management Financial modelling Risk assessment and mitigation

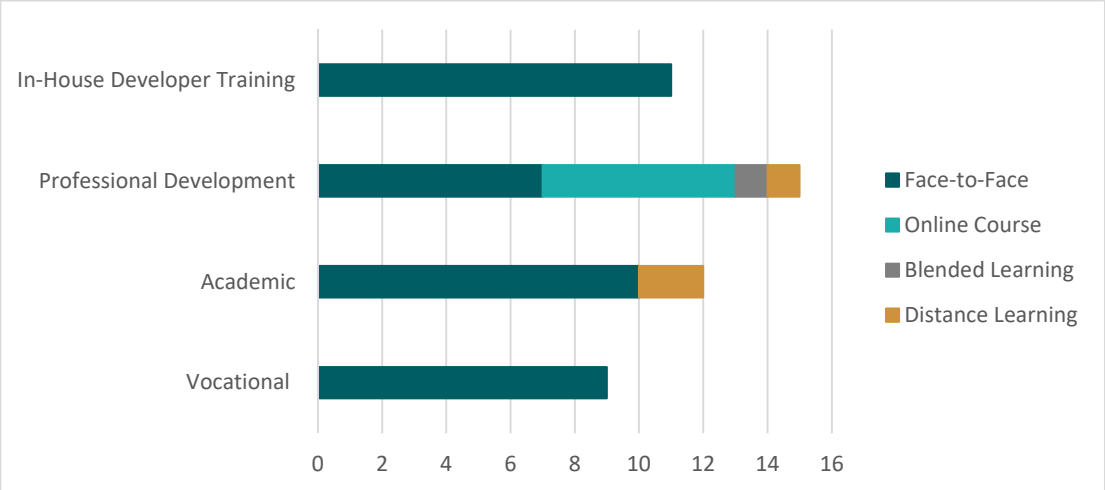
3.3 Training delivery models

Figure 2 below shows how the training programmes reviewed use different methods of delivery:

The training programmes reviewed use the following delivery methods:

- *Face-to-face delivery* - classroom training, seminars, roundtables, group exercises, workshops, assessments, field trips or on-the-job;
- *Online delivery* - e-learning, virtual meetings, webinars, or even mobile applications;
- *Blended learning* - usually a mix of face-to-face and online delivery; and
- *Distance learning*.

Figure 2: Number of training programmes reviewed broken down by programme type and delivery model used



[24] Includes customer software applications (such as CRM, call centre software, service ticketing), customer software integration (such as mobile money applications, automated SMS customer communications) and asset management and maintenance software (dashboards showing failures, optimising preventative maintenance)

Most of the training programmes reviewed use the face-to-face approach. Only six programmes use online delivery (all professional development courses) and just three use distance learning (two academic and one professional development). Interestingly, most mini-grid operators run their own "on-the-job training" and this is reflected in the fact that 11 of the training programmes we reviewed were carried out in-house. Despite this, most developers say they would prefer, if affordable, to outsource training to a qualified local institution, ideally one located close to their mini-grids.

Some professional development training providers use a blend of face-to-face and online training. Blended delivery allows for more flexibility in terms of when, where and how different types of training is done. For example, theoretical training can be done remotely or online, while practical work is done in the classroom or the field. The blended approach helps the training providers to keep their costs down and widen the audience of potential students.

The success of any programme involving online content depends on the training providers and students having access to power, computers and the internet.

3.4 Certification and accreditation

There is currently no widely recognized mini-grid industry training standard. While nearly all vocational courses are locally certified, professional development courses are often not certified and there is no regional certification system for mini-grid training.

Everyone agrees on the importance of certifying mini-grid courses and accrediting local training providers – it improves and standardises the quality of training and allows for wider delivery of courses through accredited local training institutions.

However, there is still no agreed path on how this certification should be done and, even when training providers are accredited by national authorities, there is no guarantee of common standards.

- One idea is to create nationally recognized mini-grid certificates similar to the ones widely adopted for solar engineers.
- Another is to introduce regional mini-grid certificates, so students who are certified in one country are recognised as certified by other countries in the same region. ECREEE is already in the process of piloting a regional certification system for solar PV installers in west Africa. The regional approach will only work if the relevant national institutions can agree on common standards. National institutions will probably also need to have flexibility to create their own training content to meet the requirements of developers in their country.
- Another potential solution is to develop a regional training programme that is delivered through a common knowledge platform and integrated into local training programmes through local certification or standardised tests. To ensure quality in content and delivery, the course could be developed as a massive open online course (or MOOC) hosted by an international body and delivered through an online platform or a regional organisation (e.g. APUA or ECREEE). The main problem with this approach is that the course may not be accredited by all countries and it would be up to each country to determine whether or not to adopt part or all of the available training content into existing local training programmes. Therefore, for this to work, the programme will need to provide guidelines on integration with country level training frameworks.

3.5 Feedback from developers and training providers

3.5.1 Developers' recommendations

Developers broadly agree on the kind of training they want:

- They prefer shorter, practical or field-based courses lasting a few weeks or months over courses lasting several years. One of the advantages of shorter courses is that the feedback loop is shorter, so improvements can be made more quickly.
- Following on from the above, they prefer professional development and vocational training courses which address particular skills gaps over academic courses. Developers appreciate the vocational training courses for solar engineers that exist in Nigeria and various east African countries, even though these are not necessarily mini-grid specific.
- They would like the content of mini-grid training courses to be expanded to address the gaps described above.
- They would like all training courses and training providers to be accredited by national or regional authorities in order to improve and standardise the quality of training.
- They find face-to-face training more effective than online or remote learning.
- They prefer training that is tailored for the local context and implemented locally by local training institutions. This makes the training more affordable because it saves them the cost and time of sending their staff to training centres in the city. This has to be balanced against the potentially higher cost for training providers of carrying out the training in rural areas e.g. the smaller number of students likely to attend each course.
- Developers would like to share more learnings with each other. This peer-to-peer learning can be done in many ways: group exercises in the classroom, lessons learnt from real-life case studies, guest lectures from industry practitioners, mentoring by industry experts, and on-the-job training and internship programmes. Trade associations such as AMDA can play an important role in this, for example by gathering data from developers for benchmarking purposes. Developers are particularly interested in getting benchmarking data on demand assessments, system sizing, equipment costs, capex, opex, and average electricity consumption and revenues.
- The development of training courses targeted at different types of developer (early stage versus operational, international versus local) should be considered.
- Training providers should collaborate more closely with developers and other industry stakeholders (policy makers, regulators, financiers etc.) in the development and delivery of training programmes.

3.5.2 Training Providers' recommendations

The training providers agreed with most of the views of the developers, but highlighted other areas for making training more effective and sustainable:

- They stressed the importance of not training developers in isolation. Interaction with policy makers, regulators, financiers, end-users and the different types of training providers is important to facilitate development of a mini-grid ecosystem, improve understanding between different stakeholders and develop best practices.
- They highlighted the organisational and logistical challenges of delivering mini-grid training at scale, including local language and cultural issues.
- Some of the current training programmes are provided free at the point-of-use. This is not sustainable and it will be important to find new ways of making training programmes viable for both developers and training providers e.g. charging affordable fees to developers and offering scholarships; keeping costs down through increased use of online, mobile and distance learning tools; sourcing external funding for training courses such as corporate sponsorships; developing public-private partnerships etc.

4. Review of training providers

For this report, we have reviewed 53 training providers which have experience of delivering or supporting mini-grid or renewable energy training (see Annex 1 for the full list of 53 names). This section describes some of the more interesting training providers that could potentially become partners for the AfDB.

4.1 Criteria for potential training partners

Our shortlist of potential training partners was developed using four key criteria:

- *Experience* in delivering certified renewable energy or mini-grid training in Africa;
- *Availability of funding and resources* such as personnel, infrastructure and mini-grid equipment to ensure continuity and sustainability of training;
- *Commitment* to mini-grid specific training; and
- *Geographical coverage*. Note most of the current providers operate only in one country, although some have plans to expand regionally. We have therefore focused on those providers operating in the more developed or high potential mini-grid markets.

The shortlist deliberately includes examples of two types of delivery partner:

- *Implementers* – they carry out training through physical training centres or online platforms. We have mainly focused on accredited training institutes and universities that offer face-to-face training; and
- *Facilitators* – they provide support to training implementers as part of their programme activities. This may be done through funding for the training programme, support on design of programmes, provision of equipment for use by students, facilitating regional certification, knowledge transfers through relevant networks, and, in some cases, delivery of the training itself. They include donors, large corporates, NGOs, TA providers and other organisations implementing development programmes which include training and capacity building.

4.2 Potential training partners

We provide below short descriptions of some of the more interesting training providers (divided into Implementers and Facilitators) and the countries in which they operate. For more information, please see Annex 2.

Implementers

- *Micro-Grid Academy, RES4Africa, Kenya Power Training School and University of Strathmore (Kenya and, in the future, other parts of East Africa and Southern Africa)*

  RES4Africa has established the Micro-Grid Academy in Kenya together with local partners including the Institute of Energy Studies and Research (or **IESR,** formerly the Kenya Power Training School), the University of Strathmore, St Kizito Vocational Training Institute and AVSI Foundation.

  The Micro Grid's Academy's first two weekly training courses for energy professionals took place in January and April 2018 and a third is planned in October 2018. Students will soon be able to get hands-on experience from an operating 30 kW solar mini-grid which is being built on the site of Kenya Power.

While the main focus today is more on the technical side, the Academy is planning to develop a complete mini-grid training curriculum later this year and aims to eventually train 300-500 East African students a year. It is also planning to launch courses in southern Africa (in Zambia in November 2018 and in South Africa in 2019), but it has not yet finalised its selection of local partners for these countries.

RES4Africa is a network of over 30 members from across the sustainable energy value chain including utilities, industries, agencies, technical service providers, research institutes and academia. Funding comes from the members and one of its leading members is the Italian utility ENEL. University of Sapienza Rome is an honorary member of RES4Africa and has played an important role in the setting up of the Academy.

IESR is part of the African Network of Centers of Excellence in Electricity (**ANCEE**) described below. It is registered as a Technical Industrial and Vocational Education Institution in Kenya as well as an Industrial Training Institution. It offers certified technical training courses in the electrical trade (from certificate to diploma level), for both grid tied and off-grid systems, including vocational and professional level certified training for solar technicians. It is also recognised by regional heads of state as the regional centre of excellence for capacity building in power generation, transmission and interconnectivity for the Northern Corridor Integration Projects.

The University of Strathmore Energy Research Centre does research and training on renewable technologies adapted for local conditions. With support from the GIZ Pro Solar Programme (see GIZ below), it has developed a 10kWp carport hybrid solar/ diesel system for training to solar technicians.[25]

- *KIITEC (Tanzania)*

  Kilimanjaro International Institute for Telecommunications, Electronics and Computers (KIITEC) is an accredited technical training institute based in Arusha in northern Tanzania which offers certified courses for electrical engineers. The institution has experience in providing technical training since 2009. Their approach to learning is 70% practical and 30% theoretical.

  Relevant courses offered include solar PV design and installation courses as well as domestic electrical system design and installation courses. Their courses include a 3-year diploma, professional development courses of 1-3 months and vocational training courses of 30-60 hours.

  KIITEC partnered recently with the Schneider Electric Foundation to develop and implement six-month professional level technical and non-technical training for mini-grid installers, operations managers and site managers.

- *NAPTIN (Nigeria and West Africa)*

  National Power Training Institute in Nigeria (NAPTIN) is the Nigerian government's national power training institute. It provides training to power sector personnel and coordinates

[25] More details on its other Strathmore projects can be found at https://www.strathmore.edu/serc/about/projects/.

training activities in the energy sector in Nigeria. It has experience in providing power related technical training for both on-grid and off-grid systems, as well as non-technical related professional courses such as electricity marketing and customer service, electricity trading, regulation and pricing.

NAPTIN was recognised recently as a training centre of excellence by the ANCEE and has recently started collaborating with Association of Power Utilities of Africa (**APUA – see list of facilitators below**) to deliver training to about 500 electricity professionals from Ghana and Benin through APUA's scholarship scheme.

NAPTIN partnered with GIZ under the Nigerian Energy Support Program to design and deliver certified technical courses on solar PV, micro-hydro and mini-grids to technicians and engineers. These include: solar installation, solar PV supervision, solar PV and micro-hydro mini-grid design courses. NAPTIN also offers IFC-funded scholarships for these courses.

Another interesting training institute in Nigeria is the *Ibrahim Shehu Shema Centre for Renewable Energy Research*. They offer many of the same certified solar PV courses as NAPTIN and also IFC scholarships.

- *CREEC (Uganda)*

  The Centre for Research in Energy and Energy Conservation (CREEC) is part of Makerere University in Uganda. CREEC focuses on rural electrification, productive use of energy and energy entrepreneurship. They have experience in designing, building and operating their own solar PV mini-grid system in central Uganda for research purposes. They offer certified courses in solar technician and solar testing, pico and mini-hydro design and installation, and energy efficiency and energy management.

- *Miller Centre for Social Entrepreneurship*

  The Miller Centre is a social enterprise accelerator based out of the University of Santa Clara in California in the US. They are planning to develop a module-based mini-grid training programme for Africa focused on enterprise incubation, industry best practice, and practical training based around real life mini-grid case studies and including mentoring from Silicon Valley entrepreneurs.

  They have already done something similar for last mile distribution in Africa. The Last Mile Distribution Playbook is a 12 module course based on best practices for last mile energy distribution enterprises and includes 6 months mentoring from Silicon Valley entrepreneurs. The course led to the launch of seven early stage last mile distribution enterprises across Africa.

- *SELCO Foundation*

  The SELCO Foundation is a social enterprise based in India with extensive experience in hands-on capacity building and development of locally owned and managed energy enterprises (including mini-grids). They plan to bring their capacity building model to mini-grids in Africa, starting in Tanzania.

  Their trainings are based on four main pillars: skills development, finance, policy and innovation. They are planning two types of training in partnership with the faith-based

international organization Don Bosco Technical Training Institute: a technical course targeting local individuals and productive use businesses and an energy enterprise incubation course targeting entrepreneurs.

Facilitators

- *APUA (all SSA)*

  The Association of Power Utilities of Africa (**APUA**)[26] is an international non-governmental association headquartered in Côte d'Ivoire which promotes the development of the African electrical sector. APUA has 56 active members from 46 African countries and includes 16 African power utilities.

  One of APUA's flagship programmes is the African Network of Centers of Excellence in Electricity (ANCEE), which is centred on capacity development and knowledge sharing and has been funded by the AFD (the French Development Agency) and the AfDB. It supports the development of training centres for the African power sector, with state-of-the-art equipment and facilities and sector expertise. It develops knowledge on renewable energy, facilitates the implementation of new technologies, promotes the professional development of women in the power sector and supports professional training through a scholarship program.

  We have identified two training centres from ANCEE that are particularly well qualified to act as mini-grid training implementing partners in SSA, namely the IESR and NAPTIN described above[27].

- GIZ *(Nigeria, Kenya, Uganda)*

  Gesellschaft für Internationale Zusammenarbeit (GIZ), one of the German development agencies, has helped develop solar PV and mini-grid training programmes in Nigeria, Kenya and Uganda.

  Under the Nigeria Energy Support Programme[28] GIZ, in partnership with USAID and Winrock International[29], helped the Nigerian government to develop certified courses for solar and hydro mini-grid technicians, supervisors and engineers, including training manuals for trainers. It also facilitated training of trainers in 12 technical training institutions, including NAPTIN (see above). GIZ is now working to develop a framework for continuous skills transfer and regular curriculum updates for sustainability of the courses.

  Under the Promotion of Solar Hybrid Mini-Grids (ProSolar) programme in Kenya[30], GIZ has developed a training course together with Strathmore University for solar technicians which

[26] Also known Association des Sociétés d'Electricité d'Afrique (ASEA)

[27] Other recognised training centres include Eskom Academy of Learning affiliated with Eskom (South Africa), Kafue Gorge Regional Training Centre affiliated with the Zambia Electricity Supply Corp (Zambia), the Geothermal Training Center affiliated to KenGen (Kenya), Volta River Authority (Ghana), Centre des Métiers de l'Electricité de Bingerville affiliated with Compagnie Ivoirienne d'Electricité (Côte d'Ivoire) plus several more in North Africa.

[28] https://www.giz.de/en/worldwide/26374.html

[29] https://www.winrock.org/wp-content/uploads/2018/02/Success-Story-Clean-Energy-Qualifications-in-Nigeria.pdf

[30] https://www.giz.de/en/worldwide/25332.html

certifies them to install solar-hybrid village systems of up to 10 kWp. As part of the same programme, GIZ reviewed the T1 and T2 level solar PV training developed by the Energy Regulatory Commission (ERC) for the mini-grid sector for both grid-tied and hybrid systems. It facilitated the dissemination of the T1 and T2 solar PV courses to different training institutions across Kenya to bring the training closer to rural areas. It also developed solar PV and solar hybrid mini-grid toolkits based on its mini-grid implementation work, in addition to providing training and capacity building to energy policy makers and regulators.
Finally, in Uganda GIZ helped establish a model mini-grid in Kampala for the purpose of on-the-job training of some 200 mini-grid technicians[31].

- *Schneider Electric Foundation (all SSA)*

  Schneider Electric is a French multinational corporation that specializes in energy management and automated solutions. The Schneider Electric Foundation specialises in technical, vocational and entrepreneurship training programmes which support skills development in electricity-related fields (not just mini-grids).

  They do not usually offer the programmes or training themselves. Instead they help develop training for local technical industrial and vocational training institutions, including government organisations, technical universities, faith-based organisations and other NGOs. They also train trainers and fund investments in electrical equipment.

  The Foundation has 52 training partners in Africa, of which 46 are based in SSA countries. About half are located in just five countries: South Africa (6), Burkina Faso (5), Cameroon (5), Mali (4) and Tanzania (4). Their largest regional training partner is the Don Bosco Training Institute and they work with them in five countries (Congo, DRC, Egypt, Ghana, and Kenya).

  Schneider recently organised a stakeholder's workshop in Tanzania, in partnership with ESMAP, to provide mini-grid training through KIITEC (see above) and to conduct a high-level training needs assessment for mini-grids. Following the workshop, two mini-grid training programmes were developed for delivery through KIITEC, one for mini-grid installers and operation managers (a 6 months technical course) and another for mini-grid site managers (a 6-month non-technical course).

- *ECREEE (west Africa)*

  The ECOWAS Centre for Renewable Energy and Energy Efficiency (**ECREEE**) is a centre of excellence for the Economic Community for West African States (**ECOWAS**) with a public mandate to promote regional renewable energy and energy efficiency markets. They occasionally run training workshops on mini-grids, but these are more for policy makers than developers.

  ECREEE is in the process of establishing a Regional Certification Scheme (RCS) for renewable energy in the ECOWAS region. In Phase One they are setting up a certification scheme for solar PV installers, under which the installers will be required to undergo training and take a regional exam which will lead to the provision of a certificate from ECREEE. The organisation has already identified 21 training institutions in 8 countries (Cape Verde, Benin, Burkina Faso, Ghana, Mali, Nigeria, Senegal and Sierra Leone) to participate in the pilot phase. Its implementing partners are IRENA, GIZ and the West African Economic and Monetary Union (UEMOA).

[31] https://www.giz.de/en/worldwide/61359.html

- *DFID/TEA (all SSA)*

  The DFID-funded Transforming Energy Access (TEA) is about to launch a new talent development initiative targeted at junior and mid-management levels in off-grid energy enterprises in SSA. The objective is to provide young professionals with little or no work experience with a structured learning in the off-grid sector.

  The initiative, which will be managed by Carbon Trust and implemented by an external provider, will include a graduate work placement scheme and mid-management development scheme and will also support the implementation of the sister TEA Academic Support Programme, which aims to create more synergies between universities and the needs of industry.

- *ALER (Lusophone countries)*

  Associacao Lusofona de Energias Renovaveis is a non-profit association which promotes renewables in Portuguese-speaking African countries. In October 2017, they signed a contract with UNIDO which, amongst other things, envisages the creation of a regional mini-grid training workshop for policy makers. They are looking for partners to co-fund this programme and provide technical expertise.

- *ESMAP (all SSA)*

  Energy Sector Management Assistance Program (ESMAP) is a partnership between the World Bank Group and 18 partners to help low and middle-income countries reduce poverty and boost growth, through environmentally sustainable energy solutions.

  ESMAP's Global Facility on Mini Grids works with development partners to incorporate mini-grids into World Bank investment projects, share knowledge, build local capacities and leverage partnerships. They do not run stand-alone mini-grid training programmes, but organise mini-grid learning events in different African countries.

5. Recommendations

Table 7 lists the main recommendations on mini-grid training for developers, categorised by training content, delivery models, certification and partnerships.

Table 7: Recommendations

	Recommendations
Training content	• Review curricula of existing training programmes and fill gaps in content such as business and finance, policy and regulation, health and safety, data analytics, O&M process management and software, and certain technical/engineering topics. • Prioritise training of certain core skills e.g. project management, financial modelling, risk assessment and proposal writing. • Tailor content where possible to the requirements of different types of developer and project e.g. international versus local; early stage versus operational. • Prioritise vocational and professional development courses over academic ones. • Integrate mini-grid or energy access modules more into academic renewable energy courses. • Integrate existing open source online tools for mini-grids into training courses.
Delivery models	• Focus on short courses (up to 6 months), face-to-face delivery, and practical, field-based training. • Consider blended training models which combine classroom for practical work and online or distance learning for theoretical work in order to reduce costs and reach a wider audience. • Target particular skills needs as defined above. • Expand opportunities for peer-to peer learning and knowledge exchange between the industry and academia and use industry practitioners as guest lecturers. • Train the trainers in the mini-grid content and training delivery, facilitation and assessment techniques. • Encourage more investment in demonstration mini-grids and mini-grid equipment for “hands-on” training. • Utilise or integrate existing online tools and resources.
Certification and accreditation	• Expand national accreditation of training organisations to widen the delivery reach of training programmes. • Expand local certification of vocational and professional development training programmes in order to ensure a higher and more consistent quality of training. • Certify training programmes at a regional level, not just a national level, where possible.

Partnerships	• Focus on nationally recognised local training partners that are financially sustainable, are located in attractive mini-grid markets, and have a track-record in delivering mini-grid training together with industry partners. • Build the capacity of existing in-country mini-grid training partners e.g. NAPTIN in Nigeria, KIITEC in Tanzania, CREEC in Uganda, local training partners of Schneider Electric. • Build the capacity of potential regional training partners e.g. IESR through the Micro-Grid Academy, Don Bosco Training Institute. • Work with partners to improve existing or develop new courses.

The Help Desk will contribute to the above by developing training materials over the next 15 months to address some of the curriculum gaps, working closely with and training trainers from some of the training providers mentioned in this report. We understand that the University of Strathmore will soon start developing a curriculum for the Micro-grid Academy and, to the extent possible, we will make sure our work is complementary to theirs.

Annex 1: List of 53 Training and Knowledge Providers

Name of Training / Knowledge Provider	Location of Provider	Type of Organisation
Interviews		
1. Carnegie Mellon University (CMU) - Africa Campus	USA / Rwanda	Academic institution
2. University of California, Berkeley - Energy and Resources Graduate Division	USA	Academic institution
3. University of Strathclyde	UK	Academic institution
4. AMDA	Kenya	Trade association
5. ECREEE	Cape Verde	Donor platform
6. EUEI-PDF/RECP	Germany / Africa	Donor platform
7. RECP Finance Catalyst	Germany / Africa	Donor platform
8. World Bank / ESMAP	USA	Donor platform
9. ALER	Portugal	Donor platform
10. GIZ - Kenya	Kenya	Donor platform
11. GIZ - Nigeria	Germany	Donor platform
12. IRENA	Abu Dhabi / Africa	Donor platform
13. ComAp	Asia / Botswana	Corporate
14. Miller Centre for Social Entrepreneurship (University of Santa Clara)	USA	Investment accelerator / academic institution
15. Schneider Electric Foundation / various local training partners	Germany /Africa	Corporate
16. SELCO Foundation / Don Bosco Training Institute	India/Tanzania	Foundation / Training Institute
17. World Resources Institute	USA	Research institute
18. RES4Africa / University of Sapienza Rome	Italy/Africa	Donor platform / academic institution

Name of Training / Knowledge Provider	Location of Provider	Type of Organisation
19. University of Rome	Italy	Academic institution
20. Institute of Energy Studies and Research (formerly Kenya Power Training School)	Kenya	Corporate / Training institute
Desktop Reviews		
21. Appalachian State University	USA	Academic institution
22. Arizona State University	USA	Academic institution
23. Colorado State University	USA	Academic institution
24. Duke University	USA	Academic institution
25. Frankfurt School of Finance and Management	Germany	Academic institution
26. Humbolt University	USA	Academic institution
27. Imperial College London	UK	Academic institution
28. Leicester University	UK	Academic institution
29. Loughborough University	UK	Academic institution
30. Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University	Uganda	Academic institution
31. Professional School of Education Berlin	Germany	Academic institution
32. University of Cape Town	South Africa	Academic institution
33. University of Glasgow	UK	Academic institution
34. University of Notre Dame	USA	Academic institution
35. University of Oldenburg	Germany	Academic institution
36. University of Southampton	UK	Academic institution
37. University of St. Augustine	Tanzania	Academic institution
38. University of Sussex	UK	Academic institution
39. Engerati	UK	Online platform
40. World Energy Council (Academy)	Worldwide	Industry platform

Name of Training / Knowledge Provider	Location of Provider	Type of Organisation
41. Africa Legal Support Facility (ALSF)	Côte d'Ivoire	Donor platform
42. ENEL	Worldwide	Corporate
43. ENGIE	Worldwide	Corporate
44. HOMER	USA/Worldwide	Corporate
45. Total	Worldwide	Corporate
46. SMA Solar Academy	Germany	Corporate
47. Ibrahim Shehu Shema Centre for Renewable Energy Research	Nigeria	Research institute
48. IIED	UK	Research institute
49. Clean Energy Solution Center	Worldwide	Online platform
50. KIITEC	Tanzania	Training institute
51. Renac (The Renewables Academy)	Germany	Training institute
52. TARA - India	India	Training institute
53. National Power Training Institute of Nigeria (NAPTIN)	Nigeria	Training institute

Annex 2: Details of Select Training Providers

	Training Partner/ TCOE	Regional Coverage	Training Experience	Mini-grid Experience	Resourcing
Training Implementers					
1	Institute of Energy Studies and Research (IESR), formerly Kenya Power Training School.	Kenya, eastern and southern Africa	Registered as a Technical and Vocational Education Training Institution and an Industrial Training Institutions in Kenya Earmarked by APUA to become Training Centre of Excellence Offers certified technical training courses for the electricity industry	Recently partnered with RES4Africa to host the Micro-Grid Academy (MGA) Currently developing a 30kW solar PV hybrid mini-grid to use for mini-grid training	Owned and managed by the power utility Kenya Power
2	Centre for Research in Energy and Energy Conservation (CREEC) hosted by Makerere University	Uganda	Offers certified technical courses on solar PV and hydro Experience working with partners such as UNIDO, Uganda National Council of Science and Technology (UNCST), WWF and UN Habitat	Experience in installing and maintaining a solar PV mini-grid system in central Uganda for research purposes Has lab facilities and equipment to provide hands-on training Several CREEC technicians received mini-grid training from the Micro-Grid Academy in April 2018 Working with GIZ to provide mini-grid training in Uganda	Part of Makerere University
3	National Power Training Institute of Nigeria (NAPTIN)	Nigeria, west Africa	Sectoral training institution for the Nigerian power sector Accredited as one of the TCOEs under the ANCEE Experience in technical training for on-grid and off-grid systems Provides non-technical related professional courses such as electricity marketing and customer service,	Partnered with GIZ under the NESP programme to design and deliver certified technical courses on solar PV, micro-hydro and mini-grids to technicians and engineers Offers IFC funded scholarships for the solar PV courses (including solar PV mini-grid design)	Backed by the Nigerian Government and supervised by the Federal Ministry of Power All training centres are equipped with electrical equipment for training Charges fees for its course

	Training Partner/ TCOE	Regional Coverage	Training Experience	Mini-grid Experience	Resourcing
			electricity trading, regulation & pricing. Currently in partnership with APUA to provide training to about 500 electricity professionals from Ghana and Benin through APUA's scholarship scheme		
4	Kilimanjaro International Institute for Telecommunications, Electronics and Computers (KIITEC)	Tanzania	Registered and accredited as Technical Industrial and Vocational Education Institution in Tanzania	Has developed mini-grid training programmes in partnership with Schneider Electric Recently completed a solar PV system and electrotech lab for PV training	Funded and supported by two European non-profit organisations: Foundation for Technical Education (FTE) and Action Development Education International (ADEI) Charges fees for courses
5	Ibrahim Shehu Shema Centre for Renewable Energy Research	Nigeria	Established in 2009 as a renewable energy research unit for the Umaru Musa Yar'adua University in Nigeria	Offers solar PV courses (solar PV installation, supervision, mini-grid design) developed under the NESP programme Offers IFC scholarships for these solar PV courses Collaborates with IFC to provide consultancy and project evaluation services for renewable energy projects	
6	Miller Centre for Social Entrepren-eurship (University of Santa Clara)	None. Based in California	Investment accelerator that offers practical, hands-on training and mentorship support from Silicon Valley entrepreneurs Developed training playbook for last mile distribution energy entrepreneurs in SSA	Developing mini-grid training playbook in SSA along the same lines as the model for the last mile energy distribution entrepreneurs. Looking for implementation partners	Part of University of Santa Clara in California
7	SELCO Foundation	India and Tanzania	Social enterprise with extensive experience in hand-on capacity building for local energy enterprises, including mini-grids.	Has implemented at least 4 mini-grids and surveyed 7 other potential sites. No specific mini-grid training programme or tools but does have	Backed by network of financial and advisory partners including Lemelson Foundation, Mott Foundation,

	Training Partner/ TCOE	Regional Coverage	Training Experience	Mini-grid Experience	Resourcing
				portfolio of training and capacity building programmes including training of trainers and training of financiers	Packard Foundation, GIZ, Tata Trusts and USAID
8	SMA Technologies	South Africa and Germany	Provides solar PV training through their Solar Academy in Germany, both physically and online through webinars. Physical training centre in South Africa which provides training to solar PV technicians. Partnered with GIZ and Schott Solar and Energiebau Solarstromsysteme to provide training to solar technicians in Kenya between 2011 and 2013. Partnered with Strathmore University to provide similar training in 2015. Has previously trained solar technicians in west Africa[32]	No information found	Backed by SMA
Training Facilitators					
1	Schneider Electric Foundation	Central, Eastern, Southern, Western Africa. Countries: Burkina Faso, Burundi, Chad, Cote d'Ivoire, DRC, Ethiopia, Gabon, Ghana, Guinea Bissau	Schneider Electric is a French multinational corporation that specializes in energy management and automation solutions Experience with public and private training organisations in Africa to facilitate energy-based training. Currently has 52 training partners in Africa (46 in SSA) Experience in helping design short and	Helped design and provide financial support and equipment for mini-grid training courses (e.g. KIITEC in Tanzania)	Backed by Schneider Electric

[32] https://www.sma-sunny.com/en/training-initiative-in-west-africa/

	Training Partner/ TCOE	Regional Coverage	Training Experience	Mini-grid Experience	Resourcing
		Kenya, Mali, Nigeria, Republic of Congo, Senegal, South Africa Tanzania, Togo	medium-length vocational training courses. .		
2	GIZ	All SSA Countries where GIZ is very active in mini-grids: Nigeria, Uganda, Kenya, Mada-gascar, Mali, Rwanda	One of the German development agencies Extensive experience working with training institutions to deliver renewable energy and mini-grid training, particularly in Kenya, Nigeria and Uganda Experience in partnering with and providing support to local public authorities in SSA to develop an enabling environment for the delivery of vocational and professional type training in the renewable energy sector	Facilitates development of mini-grid sector in Africa through implementation of development programmes in partnership with local governments Supports mini-grid curriculum development and implementation in SSA, including facilitating the creation of training centres, review of existing curricula, and establishment of model mini-grid systems for practical training	Backed by German government
3	APUA	SSA	International non-governmental association headquartered in Côte d'Ivoire which promotes the development of the African electrical sector. APUA has 56 active members from 46 African countries and includes 16 African power utilities	Created African Network of Centres of Excellence in Electricity (ANCEE) to improve the performance of the African electricity sector and intensify regional electrical trade by strengthening technical, managerial and governance skills.. Some ANCEE-accredited training centres e.g IESR and NAPTIN are already delivering certified mini-grid training	Backed by AFD (French development agency) and AfDB
4	ALER	Lusophone countries in Africa in central, southern	Non-profit association which promotes renewable energy technologies in	Currently no experience providing training to mini-grid developers	Donor-backed

	Training Partner/ TCOE	Regional Coverage	Training Experience	Mini-grid Experience	Resourcing
		and western Africa	Lusophone countries in Africa Supports training and capacity building particularly for policy makers and regulators through workshops and seminars Development partners include ECREEE, UNIDO and EUEI-PDF	Recently translated the Mini-Grid Policy Toolkit to Portuguese	
5	ECREEE	Western Africa. Countries: ECOWAS member states	Supports activities and mobilises funds for the creation of renewable energy and energy efficiency markets in ECOWAS states Experience providing training to policy makers and regulators in ECOWAS states Development partners include UNIDO, EU and the Spanish and Austrian development agencies	Limited experience providing training to mini-grid developers Implementing the EPASES programme which is designed to promote the uptake of clean energy mini-grids in ECOWAS states Designing a regional certification scheme for solar PV installers and technicians in partnership with several training institutions in the region. Planning something similar for clean energy mini-grid systems	Donor-backed
6	ESMAP / World Bank	All SSA	Global knowledge and technical assistance program administered by the World Bank Its three focus areas are clean energy, energy access and energy efficiency Its mission is to assist low- and middle-income countries to increase know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth	ESMAP's Global Facility on Mini Grids works with development partners to incorporate mini-grids into World Bank investment projects, share knowledge, build local capacities and leverage partnerships No stand-alone mini-grid training programmes, but organises mini-grid learning events in different African countries and publishes many mini-grid reports	Part of the World Bank